

# GATE SOLUTIONS

## CIVIL ENGINEERING

1987-2022



**Office:** F-126, (Lower Basement), Katwaria Sarai, New Delhi-110 016

**Phone:** 011-26522064 ■ **Mobile:** 81309 09220, 97118 53908

**Email:** [info.publications@iesmaster.org](mailto:info.publications@iesmaster.org), [info@iesmaster.org](mailto:info@iesmaster.org)

**Web:** [iesmasterpublications.com](http://iesmasterpublications.com), [iesmaster.org](http://iesmaster.org)



## **IES MASTER PUBLICATION**

F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016

**Phone** : 011-26522064, **Mobile** : 8130909220, 9711853908

**E-mail** : info.publications@iesmaster.org

**Web** : iesmasterpublications.com

### **All rights reserved.**

Copyright © 2022, by IES MASTER Publication. No part of this booklet may be reproduced, or distributed in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise or stored in a database or retrieval system without the prior permission of IES MASTER Publication, New Delhi. Violates are liable to be legally prosecuted.

**First Edition** : 2016

**Second Edition** : 2017

**Third Edition** : 2018

**Fourth Edition** : 2019

**Fifth Edition** : 2020

**Sixth Edition** : 2021

**Seventh Edition** : 2022

## PREFACE

The Graduate Aptitude Test in Engineering (GATE) is an All-India examination administered and conducted in eight zones across the country by the GATE Committee comprising of Faculty members from IISc, Bangalore and other seven IITs on behalf of the National Coordinating Board, Department of Education, Ministry of Human Resources Development.

The GATE score/rank is used for admissions to Post Graduate Programmes (ME, M.Tech, MS, direct PhD) in institutes like IIT and IISc, etc. with financial assistance offered by the Ministry of Human Resource Development. PSUs too use the GATE scores for recruiting candidates for various prestigious jobs with attractive remuneration.

The door to GATE exam is through previous year question papers. If you are able to solve question papers in access of 10 years, you are sure to clear the GATE exam, and open new vistas of career and learning.

The **Civil Engineering GATE 2023** book from IES Master offers detailed topic-wise solutions for the past **36 years** question papers. The emphasis is clearly on the understanding of concepts and building upon a holistic picture. So as you finish a topic, for instance, Strength of Materials, you will find all the previous years' question papers with detailed explanation under that particular topic.

The approach has been to provide explanation in such a way that just by going through the solutions, students will be able to understand the basic concepts and will apply these concepts in solving other questions that might be asked in future exams.

Every care has been taken to bring an error-free book. However, comments, suggestions, and feedback for improvement in the future editions are most welcome.

**IES Master Publication  
New Delhi**

## CONTENT

1. Engineering Mechanics .....	01 – 08
2. Strength of Materials .....	09 – 87
3. Structural Analysis .....	88 – 167
4. Construction Materials and Management .....	168 – 179
5. RCC Structure and Pre-Stress Concrete .....	180 – 250
6. Design of Steel Structure .....	251 – 303
7. Soil Mechanics .....	304 – 482
8. Fluid Mechanics .....	483 – 599
9. Engineering Hydrology .....	600 – 637
10. Irrigation Engineering .....	638 – 665
11. Environmental Engineering .....	666 – 767
12. Transportation Engineering .....	768 – 853
13. Geomatics Engineering .....	854 – 887
14. Engineering Mathematics .....	888 – 979
15. General Aptitude .....	980 – 1014
16. English .....	1015 – 1025



# UNIT-1 ENGINEERING MECHANICS

## SYLLABUS

**Engineering Mechanics:** System of forces, free-body diagrams, equilibrium equations; Internal forces in structures; Frictions and its applications; Centre of mass; Free Vibrations of undamped SDOF system.

## CONTENTS

Chapter No.	Topic	Page No.
1.	Engineering Mechanics .....	02 – 06
2.	Free Vibrations of undamped SDOF system .....	07 – 08

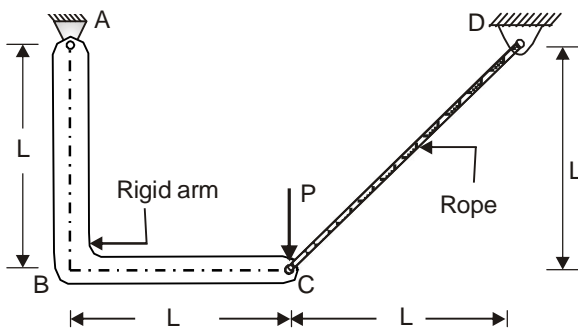
---

# 1

## ENGINEERING MECHANICS

### 1- Mark

1. An assembly made of a rigid arm A-B-C at end A and supported by an elastic rope C-D at end C is shown in the figure. The members may be assumed to be weightless and the lengths of the respective members are as shown in the figure.



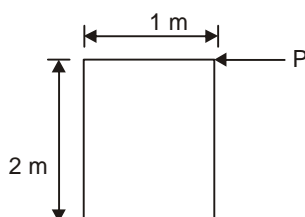
Under the action of a concentrated load  $P$  at  $C$  as shown, the magnitude of tension developed in the rope is

- (a)  $\frac{3P}{\sqrt{2}}$                       (b)  $\frac{P}{\sqrt{2}}$   
 (c)  $\frac{3P}{8}$                               (d)  $\sqrt{2}P$

[GATE-2016 SHIFT-II]

### 2- Marks

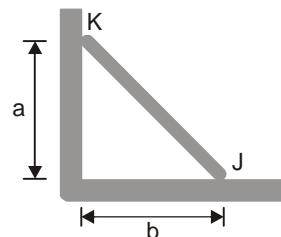
2. A horizontal force of  $P$  kN is applied to a homogeneous body of weight  $25$  kN, as shown in the figure. The coefficient of friction between the body and the floor is  $0.3$ . Which of the following statement(s) is/are correct?



- (a) The motion of the body will occur by over-turning.  
 (b) Sliding of the body never occurs.  
 (c) No motion occurs for  $P \leq 6$  kN.  
 (d) The motion of the body will occur by sliding only.

[GATE-2022 SHIFT-I]

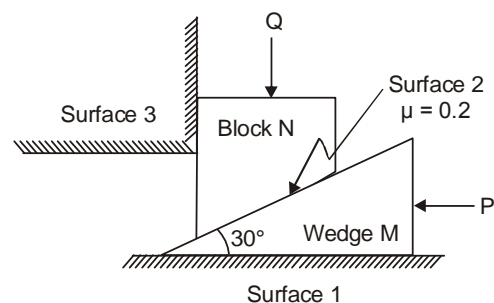
3. A uniform rod KJ of weight  $w$  shown in the figure rests against a frictionless vertical wall at the point K and a rough horizontal surface at point J. It is given that  $w = 10$  kN,  $a = 4$  m and  $b = 3$  m.



The minimum coefficient of static friction that is required at the point J to hold the rod in equilibrium is \_\_\_\_\_ (round off to three decimal places)

[GATE-2022 SHIFT-II]

4. A wedge M and a block N are subjected to forces  $P$  and  $Q$  as shown in the figure. If force  $P$  is sufficiently large, then the block N can be raised. The weights of the wedge and the block are negligible compared to the force  $P$  and  $Q$ . The coefficient of friction ( $\mu$ ) along the inclined surface between the wedge and the block is  $0.2$  all other surfaces are frictionless. The wedge angle is  $30^\circ$ .



## ANSWER KEY

1 Mark : -

1. (b)

:- : 2 Marks : -

2. (a, c)

3. (0.375)

4. (c)

5. (a)

6. (a)

7. (d)

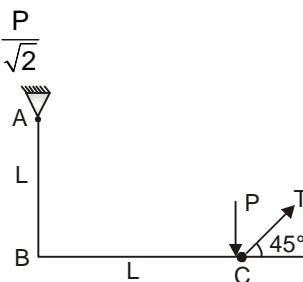
8. (d)

9. (5.5 m/s)

## EXPLANATIONS

## 1- Mark

1. (b)  $\frac{P}{\sqrt{2}}$



Taking moment about A

$$PL = \frac{T}{\sqrt{2}}L + \frac{T}{\sqrt{2}}L \Rightarrow \sqrt{2}T = P$$

$$\Rightarrow T = \frac{P}{\sqrt{2}}$$

$$\Sigma F_y = 0$$

$$N - W = 0$$

$$N = W = 25 \text{ kN}$$

So, force due to friction ( $F_s$ ) =  $\mu N$

$$= 0.3 \times 25 = 7.5 \text{ kN}$$

Hence sliding will occur at 7.5 kN.

**Case-II: Checking motion of block against tipping (over turning)**

$$\Sigma M_O = 0$$

$$-P \times 2 + W \times 0.5 = 0$$

$$2 \times P = 25 \times 0.5$$

$$P = \frac{25 \times 0.5}{2} = 6.25 \text{ kN}$$

Block will overturn at  $P = 6.25 \text{ kN}$

As it not mentioned that load is increased gradually, hence

(i) for  $P < 6.25 \text{ kN}$ , No motion occurs

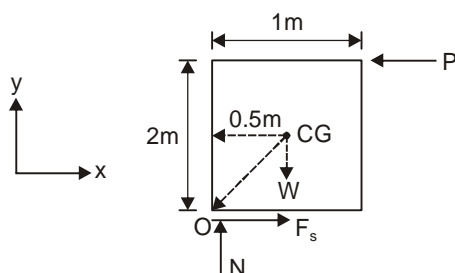
(ii)  $6.25 \leq P < 7.5 \text{ kN}$ , motion of block will occur by overturning only

(iii) For  $P > 7.5 \text{ kN}$ , motion of block will occur both by sliding and overturning.

Hence, option (a), and (c) are correct.

## 2- Marks

2. (a, c)



Motion of block will occur in two ways, the block may slide to the left or it may tip about edge O.

**Case-I:** Checking motion of block in sliding

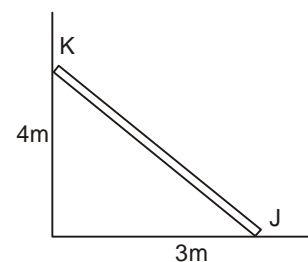
$$\Sigma F_x = 0$$

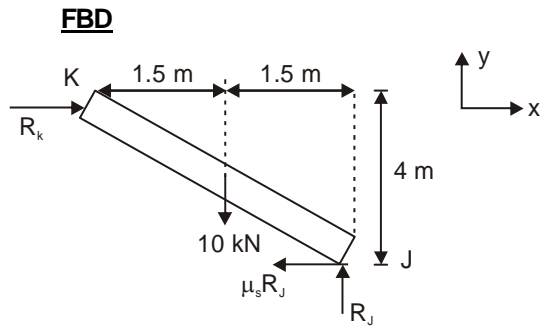
$$P - F_s = 0$$

$$P = F_s$$

and

3. (0.375)





$$\sum F_V = 0$$

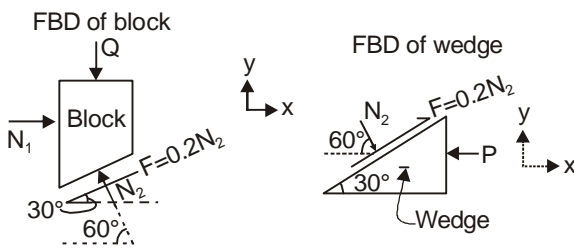
$$\Rightarrow \boxed{R_J = 10 \text{ kN}}$$

$$\sum M_K = 0$$

$$\Rightarrow 10 \times 1.5 + \mu_s R_J \times 4 - R_J \times 3 = 0$$

$$\Rightarrow \mu_s = \frac{10 \times 3 - 10 \times 1.5}{10 \times 4} = 0.375$$

4. (c)



$$\sum F_y = 0 \text{ on block}$$

$$N_2 \sin 60^\circ - 0.2 N_2 \sin 30^\circ - Q = 0$$

$$Q = 0.766 N_2 \quad \dots(i)$$

Putting in wedge

$$\sum F_x = 0$$

$$0.2 N_2 \cos 30^\circ + N_2 \cos 60^\circ - P = 0$$

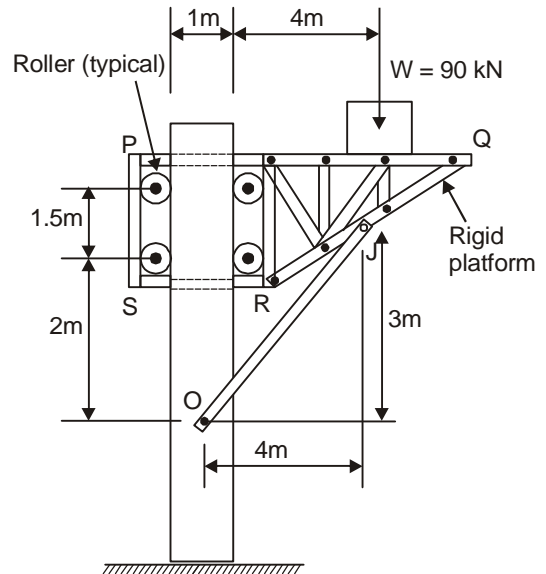
$$P = 0.67 N_2$$

$$\text{or } P = 0.67 \times \frac{Q}{0.766}$$

$$= 0.875 Q = 0.9Q$$

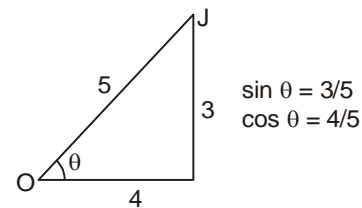
$$\therefore \alpha = 0.9$$

5. (a) Let the bar OJ is inclined at 'θ' with horizontal.



According to the assembly, the weight  $W = 90$  kN must be equal to vertical component of force in member 'OJ'.

$$\text{Hence } F_{OJ} \sin \theta = 90 \text{ kN}$$



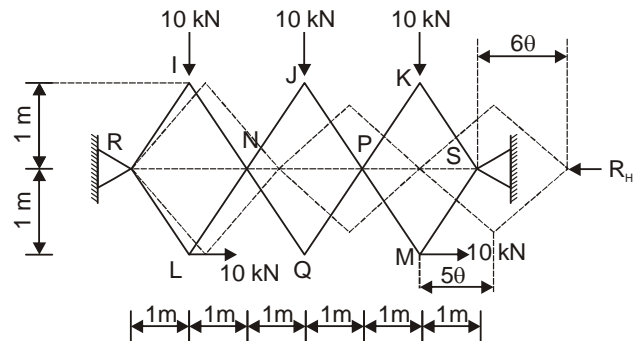
$$\Rightarrow F_{OJ} = \frac{90}{0.6}$$

$$\Rightarrow \boxed{F_{OJ} = 150 \text{ kN}}$$

Now at 'O', horizontal component of reaction,  $H_O = F_{OJ} \cos \theta = 150 \times 0.8$

$$\Rightarrow \boxed{H_O = 120 \text{ kN}}$$

6. (a)



Let us give angular displacement to members RI and RL an amount 'θ' as shown.

Due to which the resulting displacements are